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THESIS

WIRELESS COMMUNICATIONS INFRASTRUCTURE FOR COLLABORATION IN COMMON SPACE

by

Kivanc METINGU

March 2004

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13. ABSTRACT (maximum 200 words)

Modern technology is making virtual environments a part of daily life. However, some constraints about the usage of virtual environments, such as the need for high performance and well-configured computers, prevent users from accessing virtual environments in some places other than special computer rooms. Mobile devices may be used to solve this limitation in a virtual environment.

The remote-control approach to access virtual worlds on the Internet or on a corporate network is a new concept that opens new doors to users. First step of this approach is already in use, such as games implemented for mobile devices using the screen of a mobile device as display, and has given satisfying results for some users. This research will take the user, who not only wants to be mobile but also does not want to sacrifice high resolution textures and complex models, closer to his/her goal.

Mobile devices provide mobility to the user, but sacrifice not only the reality of the virtual environments but also screen size, which is very important for visibility of complex virtual environments. The hybrid approach with wireless internet connection by using mobile devices as remote control gives the user the advantages of mobility over desktop PCs. On the other hand, the realism provided by high-quality PCs on the server side exceeds the capabilities of mobile devices.

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WIRELESS COMMUNICATIONS INFRASTRUCTURE FOR COLLABORATION IN COMMON SPACE

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Modern technology is making virtual environments a part of daily life. However, some constraints about the usage of virtual environments, such as the need for high performance and well-configured computers, prevent users from accessing virtual environments in some places other than special computer rooms. Mobile devices may be used to solve this limitation in a virtual environment.

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I. INTRODUCTION

This research describes innovations, technology and concepts related to a new system that supports wireless control of entities in a virtual environment and also provides the explanation and implementation of this system.

These two concepts are used as the starting point:

- Virtual Environments
- Using Mobile Devices as a Remote Control

Modern technology is making virtual environments a part of daily life. However, some constraints about the usage of virtual environments, such as the need for high performance and well-configured computers, prevent users from accessing virtual environments in some places other than special computer rooms. Pocket PC, a computer that fits in the palm of your hand which runs the latest Windows CE Operating System, may be used to solve this limitation in a virtual environment.

Although some devices, like Pocket PC and some new types of hybrid phones, do offer more memory, most devices on the market are so-called thin clients that were simply not created with the file storage and access in mind. Windows CE/Pocket PC-based devices are used more like small mobile PCs, which explains why devices like the iPAQ have more memory.

The remote-control approach to access virtual worlds on the Internet or on a corporate network is a new concept that opens new doors to users. First step of this approach is already in use, such as games implemented for mobile devices using the screen of a mobile device as display, and has given satisfying results for some users. This research will take the user, who not only wants to be mobile but also does not want to sacrifice high resolution textures and complex models, closer to his/her goal.

Current solutions to accessing virtual environments:

- Traditional Computers: Almost perfect quality scenes, artificial intelligence embedded virtual environments; but no mobility.
- Mobil Devices: World-wide mobility, poor scene quality.

By using the current technology wisely, a hybrid approach can improve usage of Virtual Environments. Mobile devices provide mobility to the user, but sacrifice not only the reality of the virtual environments but also screen size, which is very important for visibility of complex virtual environments. The hybrid approach uses mobile devices as a remote control, a high quality computer as a server, a display unit as big as needed, and wireless internet to connect them. Actually even only entity data may need a lot of memory space; nobody wants to or can store sizeable data on a mobile device. Entity data should be stored remotely and the users use his/her mobile device as a remote control device. Users send commands as simple text by using GUI elements, such as buttons and sliders. The GUI can be implemented in Java or even with VRML using Cortona Pocket PC Client.

Bluetooth technology, an alliance between mobile communications and mobile computing companies to develop a short-range communications standard allowing wireless data communications, can be considered for connecting clients and server. Bluetooth amplifiers can beam information from device to device up to 100-meter range without the need for uninterrupted sight lines. However, 802.11b and Bluetooth occupies the same 2.4GHz band and therefore 802.11b operations interfere with Bluetooth. Because 802.11b is more effective than Bluetooth currently, and also the usage spectrum of the devices with Bluetooth is not broad enough yet, 802.11 will be used for main internet connection in this research. Detailed information can be retrieved from following URL: www.iec.org/events/2002/natlwireless_nov/featured/d2_godfrey.pdf Bluetooth technology will be used for file transfers between PC and Pocket PC and installing necessary platforms, such as the JeodeRuntime java platform. In the near future Bluetooth Technology may enable new faster ways to transmit

information wirelessly from remote locations. Therefore this research may be modified and improved using Bluetooth in the future.

A. RESEARCH OBJECTIVES

The objective of this thesis, and of the research upon which it is based, is to improve collaboration in common space by providing a new system model for wireless entity control in virtual environments.

The main deliverable of this thesis is a demonstration of a new system model which will provide both mobility and reality by implementing a remote control approach for virtual environments using mobile devices. The new model will be applied to a simple chess game.

B. SCOPE

Since this research is unclassified, the given virtual environment will only be a simple chess game without any deep logic for demonstration purposes. Because there will be no prompts or warnings the rules will be applied by users as in real life chess game. Real virtual environments, which have extreme complexity, will not be provided in this research.

Once the research is completed, the same model may be used for other virtual environments and relevant areas with a few modifications on both server and client sides.

C. METHODOLOGY

Research progressed in four main phases: 1) Review of current related technologies, such as Wireless Technologies and Graphics Technologies; 2) Review of current systems similar to the demonstration-product of this research, such as Mobile printing system and Chess Game for PCs and Pocket PCs; 3) Identification of a better possible server-client system for a chess game that doesn't sacrifice reality while providing mobility by using current technology; 4) Development of the demonstration server-client application which provides more effective usage of the mobile devices for a remote control in a virtual environment.

D. RESEARCH QUESTIONS

The primary goal of this thesis is to answer the following questions:

- By implementing software programs for mobile devices, can we create human collaborative interaction in distributed common space of virtual environments with mobile users?
- By implementing software programs for mobile devices, how can we widen the usage of virtual environments in daily life?
- By applying a new server-client model for collaborative mobile device applications can we improve reality and mobility?
- With a prototype capability can we identify constraints, limitations, performance?

E. OUTLINE OF THESIS

The rest of this thesis will adhere to the following outline.

- Chapter II Background
- Chapter III Development of a New Wireless Server-Client System Model
- Chapter IV Implementation
- Chapter V Test and Performance
- Chapter VI Conclusions and Future Work

II. BACKGROUND

A. WIRELESS TECHNOLOGIES

1. Bluetooth

Bluetooth is a short-range wireless technology used to create PANs (Personal Area Networks) enabling seamless voice and data connections between both mobile and stationary devices. For instance, it specifies how mobile phones, WIDs, (Wireless information device: a PDA or similar-sized pocket computing device with built-in wireless connectivity, and that hence permits direct mobile access to the Internet without having to be interfaced to a mobile phone) and computers interconnect with each other, with computers, and with office or home phones. Bluetooth allows you to leave your phone in your pocket, while talking on your phone with a Bluetooth headset - with no wires. You can also exchange contact or scheduling information with other Bluetooth-enabled phones nearby, or send such information to a nearby Bluetooth-enabled printer. Another common use is to give a laptop computer or a PDA (Personal Digital Assistant) wireless high-speed Internet access via Bluetooth and your phone. Many newer automobiles also have Bluetooth, which can interface with a phone in a pocket, to allow automatic hands-free phone capability. More innovative uses include playing a game against someone with a similar phone nearby.

Version 1.0 requires users to register the connection between the 2 devices while version 1.1 allows a Bluetooth device to communicate with up to 8 devices.

2. Wi-Fi (802.11b 802.11g) Wireless Ethernet

Wi-Fi, short for "wireless fidelity", is the popular term for a high-frequency wireless local area network (WLAN). Wi-Fi is specified in the 802.11b specification from the Institute of Electrical and Electronics Engineers (IEEE) and is part of a series of wireless specifications together with 802.11, 802.11a and 802.11g. All four standards use the Ethernet protocol. Products certified as Wi-Fi by Wireless Ethernet Compatibility Alliance (WECA) are interoperable with each

other even if they are from different manufacturers. A user with a Wi-Fi product can use any brand of Access Point with any other brand of client hardware that is built to the Wi-Fi standard at the 2.4 ghz spectrum using direct sequence spectrum (DSS).

Unless adequately protected, a Wi-Fi wireless LAN can be susceptible to access from the outside by unauthorized users. Companies that have a wireless LAN are urged to add security safeguards such as the Wired Equivalent Privacy (WEP) encryption standard, the setup and use of a virtual private network (VPN) and a firewall. Many airports, hotels, and fast-food facilities now offer public access to a Wi-Fi network; these are known as hotspots. Although many charge a daily or hourly rate for access, some are free.

3. GSM/GPRS

GSM, short for Global System for Mobile communication, is one of the leading digital mobile telephone systems widely used in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA), which allows eight simultaneous calls on the same radio frequency, and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). It operates at either the 900 MHz or 1800 MHz frequency band.

GSM has over 120 million users worldwide and is available in 120 countries. Because many GSM network operators have roaming agreements with foreign operators, users can often continue to use their mobile phones when they travel to other countries.

American Personal Communications (APC), a subsidiary of Sprint, is using GSM as the technology for a broadband personal communications service (PCS). This service will ultimately have more than 400 base stations for the palm-sized handsets that are being made by Ericsson, Motorola, and Nokia. The handsets include a phone, a text pager, and an answering machine.

GSM together with other technologies is part of an evolution of wireless mobile telecommunication that includes High-Speed Circuit-Switched Data

(HCSD), General Packet Radio Services (GPRS), Enhanced Data GSM Environment (EDGE), and Universal Mobile Telecommunications Service (UMTS).

GPRS is a packet-based wireless communication service that promises data rates from 56 up to 114 Kbps, compared with current system's 9.6 kilobits, and continuous connection to the Internet for mobile phone and computer users.

GPRS, which supports a wide range of bandwidths, is an efficient use of limited bandwidth and is particularly suited for sending and receiving small bursts of data, such as e-mail and Web browsing, as well as large volumes of data. The higher data rates will allow users to take part in video conferences and interact with multimedia Web sites and similar applications using mobile handheld devices as well as notebook computers. GPRS is based on GSM communication and will complement existing services such circuit-switched cellular phone connections and the Short Message Service (SMS). GPRS will also complement. GPRS is an evolutionary step toward Enhanced Data GSM Environment (EDGE) and Universal Mobile Telephone Service (UMTS).

4. WANDA

WANDA, short for Wireless Any Network Digital Assistant, is a new "tri-wireless" PDA concept designed by TI (Texas Instruments). A Pocket PC-based PDA, the WANDA supports GSM/GPRS cell networks, Bluetooth, and Wi-Fi. WANDA is a modular architecture so it can support one, two or all three of the wireless capabilities TI to enable simultaneous phone calls, web browsing, mobile commerce or printing by combining 802.11b and Bluetooth wireless capabilities, along with a GSM/GPRS tri-band radio, into a single low-power handset design. It sports Microsoft's Pocket PC operating system. Detailed specifications can be obtained from the following URL: http://focus.ti.com/docs/apps/catalog/general/general.jhtml?templateId=1101&path=templatedata/cm/general/data/wire_conceptdesign2

B. GRAPHICS TECHNOLOGIES

1. Content Development

a. Modeling: High-End Graphics Systems; 3ds Max, Maya

Discreet's 3ds Max is a widely-used 3D modeling, animation, and rendering solution for film, television, games and design visualization. 3ds Max 6, the last version, is used for almost everything in the entertainment industry; from game design to highly advanced movies like “The Matrix: Reloaded” and “The Last Samurai”. 3ds Max gives you the ability to create 3D models, special effects, and much more; many of which are used in high-end films these days. It is popular due to the fact that it is very universal; there are several third party applications and plug-ins made for this application as well as its interchangeableness with 3D tracking systems, 2D compositing software, nonlinear editing systems and other animation solutions.

Maya Complete, like 3ds Max, makes the foremost 3D content creation tools accessible to a broad range of computer graphics professionals in the film, broadcast, industrial design, visualization, game development and web design industries. It is one of the leading full 3D production solutions. Maya Complete is available for Windows 2000 Professional, Windows XP Professional, Mac® OS X, SGI IRIX® and Linux operating systems..

b. Libraries: 3D Cafe, 3D Total, Amazing 3D

3D Model Libraries are extremely useful for the 3D artist who wants to enrich their 3D worlds by using already created 3D models. Using these meshes can easily shorten the project’s completion time. Models are usually offered in the following file formats: .x3d,.3ds, .max, lws, vrml (.wrl), .dxf, .obj, or .cob. The SAVAGE group is building a large archive of dynamic 3D military models and authoring tools using Extensible 3D (X3D) graphics. 3D Cafe, Amazing 3D Graphics, 3D Daily Library are also good examples of the 3D Model Libraries.

c. Web-based Graphics Editors: VRMLPad, X3D-Edit, Extrusion Editor

VRML (Virtual Reality Modeling Language) is a language for describing three-dimensional (3-D) image sequences and possible user interactions to go with them. Using VRML, you can build a sequence of visual images into Web settings with which a user can interact by viewing, moving, rotating, and otherwise interacting with an apparently 3-D scene.

VrmlPad is a flexible authoring tool from ParallelGraphics that allows a user to design and develop professional VRML content. VrmlPad may be used to create VRML worlds for publishing on the World Wide Web. VrmlPad has powerful editorial abilities and visual support for the scene graph tree and resource operations. VrmlPad also fully supports the VRML 97 specification. VrmlPad 2.0 also includes an integrated script debugger that makes the process of finding and fixing errors and bugs in the VRML scripts considerably easier. It lets users run vrmlscripts step by step, set breakpoints, and watch the values of fields at runtime. Extrusion Editor, a visual plug-in for ParallelGraphics' VrmlPad, offers you an effective method for creating and editing extrusion models. It also provides visual support for every step in the creation of extrusions; all manipulations with the extrusion parameters are immediately displayed in the 3D window. One of the examples of extrusion generators can be found at the URL:

Extensible 3D (X3D) is a software standard for defining interactive web- and broadcast-based 3D content integrated with multimedia. This is basically an XML version of the VRML 2.0 file format specification. X3D is intended for use on a variety of hardware devices and in a broad range of application areas such as engineering and scientific visualization, multimedia presentations, entertainment and educational titles, web pages, and shared virtual worlds. X3D is also intended to be a universal interchange format for integrated 3D graphics and multimedia on the web. X3D is the successor to the VRML, the original ISO standard for web-based 3D graphics (ISO/IEC 14772). X3D improves upon VRML with new features, advanced application programmer interfaces, additional data encoding formats, stricter conformance, and a

componentized architecture that allows for a modular approach to supporting the standard.

X3D has a rich set of features to support applications such as engineering and scientific visualization, multimedia presentations, entertainment and educational titles, web pages, and shared virtual worlds.

http://www.realism.com/Web3D/Examples/Extrusion/_frame.html

d. Performance Tips, VRML Optimizers, Converters

As mentioned before, because mobile devices have limited memory and CPU (Central Processing Unit) capability 3D artists must be careful about performance of their VRML files. On the internet there are a lot of VRML tutorials and performance tips. The following tips can help to improve the performance by decreasing the size of the file and using a better structured scene graph: You can find detailed tips at this URL: http://www.blaxxun.com/developer/contact/3d/vrml/

- Reduce polygons and simplify geometry
- Remove unneeded faces
- Use instancing (DEF once, USE many times)
- Don't disable backface culling (solid FALSE) if it is not totally necessary
- Use unlit textures; ImageTexture only
- Share identical Texture, Material and Appearance nodes
- Limit the number of lights; directional Lights are fastest
- Help the browser by limiting the amount of active nodes
- Using a switch node currently unneeded / invisible parts can be enabled / disabled
- Complex animations can be disabled by disabling TimeSensors
- Reduce the transformations

Internet Model Optimizer is a tool that provides an efficient way to optimize complex 3D models, which originate from CAD (Computer Aided Design systems and other sources, for use on the Internet. Some CAD models may not be used on the Internet because of their huge sizes. Optimizers allow users to dramatically accelerate the rendering of these models by polygonal simplification and offer a wide range of optimization modes - from batch processing to manual mode - plus the ability to optimize selected parts of the model only. Polygon simplifications are managed by highly complex optimization algorithms designed to maintain the visual aspects of the original object.

PolyTrans and its more comprehensive version, NuGraf, provide a complete set of precise and quality import/export converters for the most popular industry standard 3d model formats. These are translators that can convert entire files from one format to another in a manner such that the exported file can be loaded and rendered in a target animation system with little or no changes necessary. Because the modeling editors do not provide the same tools, 3D artists may want to convert a file to another file type to use with a desired editor.

Crossroads, a freeware 3D viewer and converter software, converts meshes into various popular file formats. However it does not have any modeling capabilities so it may be used by those who need simplicity. 3D artists can find detailed information about Crossroads from the URL: http://www.europa.com/~keithr/crossroads/ .

C. CURRENT SIMILAR SYSTEMS

1. Mobile Printing System

AXIS 5800 Mobile Network Print Server is the first print server that supports wireless printing. The Mobile Printing vision from Axis involves wireless printing from mobile devices such as mobile/cellular phones, laptops, PDAs and digital cameras but also traditional PCs. Mobile Printing uses radio communication to transport the print data. Mobile Printing combines data connectivity and mobility.

In the Wireless Printing scenarios, the information to be printed resides in the memory, hard disk or other storage of the mobile device. Local refers to the physical location of the print content; i.e., calendars and e-mails found locally in your mobile phone/PDA or a document residing in your laptop. With Mobile Printing technology, you are free to print wherever you are in the office, whenever you want. Typically mobile phones do not include a lot of memory and computing capabilities, so printer drivers for PCs cannot be used for mobile phones. Furthermore, printing from a PDA allows users to output anything stored in the PDA such as e-mails, e-books, documents, calendar items, etc.

Building on the Wireless Printing approach, Axis' vision for further Mobile Printing Solutions is printing documents that are accessible over the Internet without first having to download them to a mobile device. Normally a mobile phone or a PDA would not have the capabilities of storing and displaying a large document, which makes it even more appealing to print the documents using the mobile device as a remote control. Remote Printing includes the same basic functionality as Local Printing; i.e., discovery and printer capability inquiry.

2. Computer Games

Because the demonstration of this research will be a 3D Chess Game, some examples of current games are listed below. For details URLs are provided.

a. Chess Games for PCs

Hoyle Majestic Chess

URL: http://www.gamespot.com/pc/puzzle/hoylemajesticchess/

Enigma Chess Game

URL: http://www.enigma.vu/chess.htm

b. Chess Games for Mobile Devices

CHESS for Pocket PC

URL: http://www.995soft.com/995chessppc/

Kasparov Chessmate by Jamdat (Pocket PC)

URL: http://www.hexacto.com/game_kasparov.php

c. Handheld Devices Specially for Chess Game

Excalibur Electric Compact Hand held LCD Chess Game 375

URL: http://store.yahoo.com/comfort1st/exelcohahelc.html

d. Multi-User Chess Game for PC

Chess Brain Chess Network

URL: http://www.chessbrain.net/cbindex.html

e. Screenshots, Pros and Cons

PC *(*Hoyle Majestic Chess*)*

Pros: High quality graphics, adjustable strength levels, multiplayer, chat capability.

Cons: Weak Mobility -Cannot be used with Mobile Devices-

Neutral: Tournament Feature with Computer generated players.

Figure 1. Hoyle Majestic Chess

Pocket PC (Jamdat Mobile)

Pros: Mobility, Chat capability

Cons: Weak graphics compared to PC; Small Display.

Figure 2. Jamdat Mobile Chess

Multi-user PC

Chess Brain Network

Pros: Distributed network to play a game against a super computer.

Cons: Weak Graphics, Weak Mobility -Cannot be used with Mobile Devices-

Figure 3. Chess Brain Network

Chess Set

Leather-Cased Glass Chess Set

Pros: Real, Selectable material

Cons: Expensive, heavy

Neutral: Partly Mobile.

Figure 4. Leather-Cased Glass Chess Set

III. DEVELOPMENT OF NEW WIRELESS SERVER-CLIENT SYSTEM MODEL

A. IDENTIFICATION OF NEW MODEL FOR MORE EFFECTIVE SYSTEM

1. Definition

After examining the current similar systems in the previous chapters, it can be seen that graphics applications for mobile devices lack visual quality. The problems are the low resolution and the small size of the display, even anti-aliasing cannot be enabled due to the loss in the fps (frames per second) of the display, enabling anti-aliasing is not recommended for games. Also it is apparent that the more interactive a game is, the more it is fun. Interactivity may even sometimes create overhead for a PC CPU and this problem may cause damages on the PC. Implementing a game for a mobile device requires serious deign considerations. Optimization of written code is very important. Even at the design phase, assumptions must be made very carefully since post-optimization of a code may not be a solution. These days, Java is one of the most widely used languages for interactivity of the games. Java Code Optimizers may be very effective for reducing the size of the Java files driving the game. However even this enhancement may not be sufficient and one may have to sacrifice some nice aspects of the game.

Although sacrificing the graphical interface and the interactivity of the game may be acceptable for the coder, users may not tolerate it. What users want is realistic high resolution graphics and total control of game play. This means that you need more memory space and a powerful CPU. We are going to plan a design for people who are not patient enough to wait for the production of a new mobile device as powerful as PCs.

The fundamental constraint on PCs is lack of mobility. It is a simple concept: There must be something better than a computer. After notebooks were first introduced there was a tremendous trend about buying a notebook just for the sake of being mobile. While the modern world is pushing people to be more and more mobile, for businessmen who want to be ahead of their colleagues,

mobile devices become a must-have helper for presentations, preparing spreadsheets and their common activities.. You may find more information about how wireless becomes a business advantage at this URL: http://media.wiley.com/product_data/excerpt/ 39/04711503/0471150339.pdf

2. Description and Design

Using mobile device as a remote control for printing documents also provides a new point of view on using mobile devices. A hybrid product or a design which can combine both PC and mobile device's best aspects may be a solution without sacrificing reality of graphics, interactivity and of course mobility. A hybrid product approach has the physical limitation such as for a light-weight mobile device needing to keep screen size small. Until super-light screens become very common, mobile devices cannot pass this physical barrier.

The second approach is a new design that uses both mobile devices and high-performance PCs. WLAN (Wireless Local Area Network) is a solution but does not provide wider mobility. Internet is the source that can provide us global mobility. If we can use mobile devices as remote control for the web-enabled virtual environments or games we can have mobility of mobile devices and realistic graphics of high-performance PCs. Imagine you are in a café and you want to play a chess game with someone in the same café. After finding someone to play with you connect to a site and open a new chess game and give a name to game. Your partner goes to same site and finds your chess game's name and connects to it. Actually what you see on your mobile device screen is a simple GUI interface similar to TV remote controls. What we obtain here is mobility since even the place and the people are random; they connected to the same game via internet. You and the other people in the café can watch the shared state of this chess game at the same site via big screen projected by a high-performance PC and projector owned by the café. Nobody has to get together around the players to be able to watch the game.

The following image is one of the possible designs of this model.

Figure 5. Remote 3D Chess Game Design

B. NEEDS AND REQUIREMENTS

1. Hardware Needs

We are going to use iPAQ 5000 series Pocket PCs for this project as the client side of the application. The reasons of choosing this model are its wireless capability, 802.11 and Bluetooth, more memory space compared to earlier versions and its faster CPU. We are going to use a notebook with wireless capability, 802.11 and Bluetooth, and a digital projector. A high resolution digital camera will be used for good quality textures.

2. Software Needs

For modeling and editing chess game objects X3D, VrmlPad, 3ds max, Wings3D, Crossroads for file conversion and built-in plug-ins, 3ds max optimizer for optimizing the models, java files for interactivity, Textpad as java editor, JeodeRuntime java platform to run the java application on iPAQ Pocket PC, for

synchronization of PC and Pocket PC and ActiveSync transferring the files from PC to Pocket PC. Pocket PC Cortona is used as client side GUI.

3. Final Product Requirements

We will be able to change the positions of the chess pieces by using the iPAQ Pocket PC. We are going to use UDP (User Datagram Protocol), a connectionless protocol that, like TCP, runs on top of IP networks. Unlike TCP/IP, UDP/IP provides very few error recovery services, offering instead a direct way to send and receive datagrams over an IP network. It's used primarily for broadcasting messages over a network. Client side GUI interface will be implemented in Java. However an optimized VRML version of the chess game may be provided for client side GUI.

IV. IMPLEMENTATION

A. SETTING THE NECESSARY ENVIRONMENT

1. Setting Necessary Platform for personal Pocket PC

To be able to run demonstration chess applications, after synchronizing the Pocket PC with a PC using ActiveSync, install Jeode runtime to the Pocket PC. Then copy KivancPocketChess.jar files to the Pocket PC. After accomplishing previous steps, first run ChessServer.java, which is the server in the demonstration server-client system, on the PC and then run ChessClient.java on the Pocket PC, which is client, by entering the arguments to EVM. Please refer to the README.txt file provided in the java folder under demonstration folder for further explanation about running Demonstration on Pocket PC and PC.

Because the implementation process needs a lot of testing entering the arguments from EVM can be frustrating. Please read the "Creating a shortcut for EVM" section in the README.txt file to create a shortcut for your own applications. A shortcut for running the Client of the demonstration on the Pocket PC is provided in the demonstration folder on Pocket PC. It can also help to have an idea how to create shortcuts for future personal applications.

Another reason for these explanations is to help the students, who want to continue this research, by providing complete directions running their own applications in the future.

a. Connecting Pocket PC to PC and Synchronization

Synchronization is the main concept for mobile devices to communicate with the PC. This section explains how it is achieved on an iPAQ in order to upload the executables to the Pocket PC.

ActiveSync synchronization program has to run on both PC and Pocket PC. New Pocket PCs come with this program already installed. However, you can download the latest version of this program from the Microsoft web site for your PC free at:
http://www.microsoft.com/windowsmobile/resources/downloads/pocketpc/actives

ync37.mspx or you can use your iPAQ CD to install ActiveSync into your PC. Now both devices have been installed and are ready to connect. When you connect the iPAQ USB port to your PC, the following prompts appear..

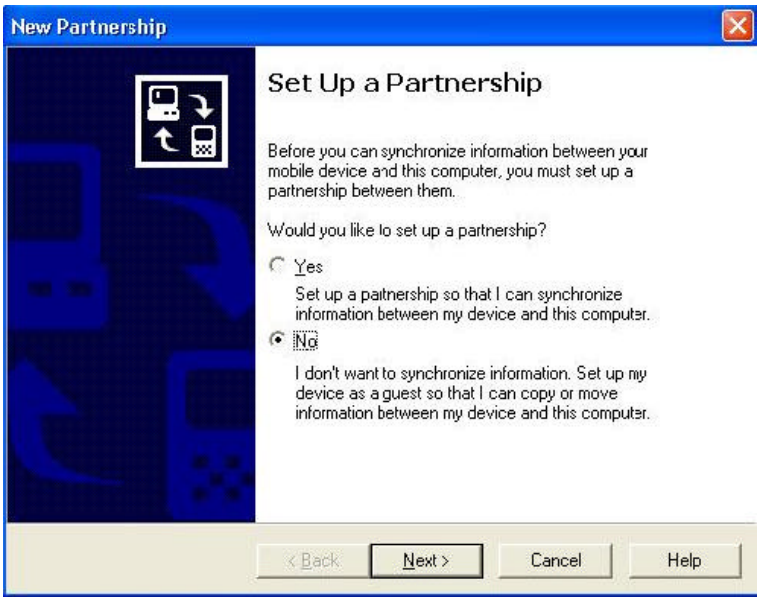

Figure 6. Setting a Partnership

Two options are presented: Partnership or Guest connection. A Guest connection is enough for copying and moving the files between the device and the computer. When the Guest connection is established, the Pocket PC's directories can be browsed. Now it is a part of the computer directory on the PC.

With the ActiveSync window, options and other functionalities about this connection are presented. Figure 7 shows the ActiveSync window and its tools.

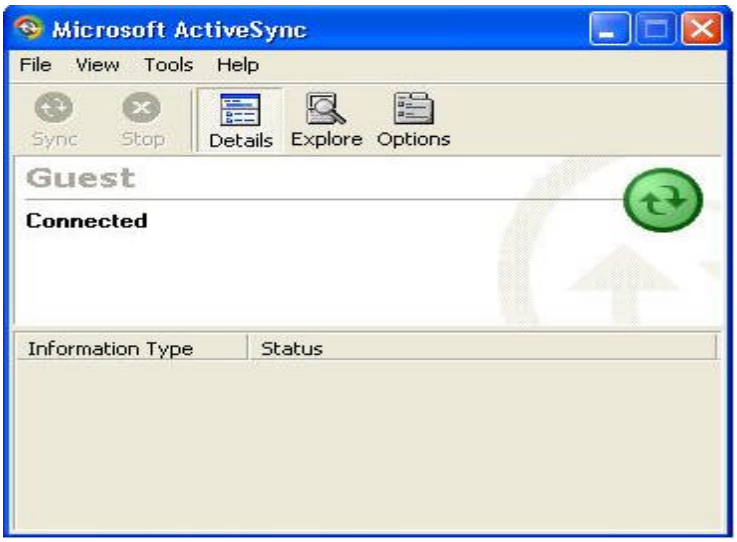

Figure 7. ActiveSync Dialog box

b. Installation of JeodeRuntime

After establishing the connection between the devices, now it is time to install one of the run time environments into the Pocket PC. There are two options: JeodeRuntime or Personal Java. JeodeRuntime is used because it comes on the Pocket PC's distribution CD. Microsoft provides JeodeRuntime on the iPAQ CD. JeodeRuntime is a fully-certified implementation of Sun's PersonalJava 1.2 specification The latest Java DK (Development Kit) specification that can be used with JeodeRuntime is the JDK 1.2 development kit specification.

When the JeodeRuntime emulator is installed into the PC, it is automatically installed to the Pocket PC. Now the Pocket PC is ready to run Java native applications and applets. Java source code cannot be developed on iPAQ; only Java jar files are executed. To run a Java application using Jeode*Runtime*, it is needed to copy the user defined application classes, libraries and properties to iPAQ Java files can be run on Pocket PC by using EVM (Emulator Virtual Machine) console provided by JeodeRuntime. Figure 8 shows the EVM console on iPAQ.

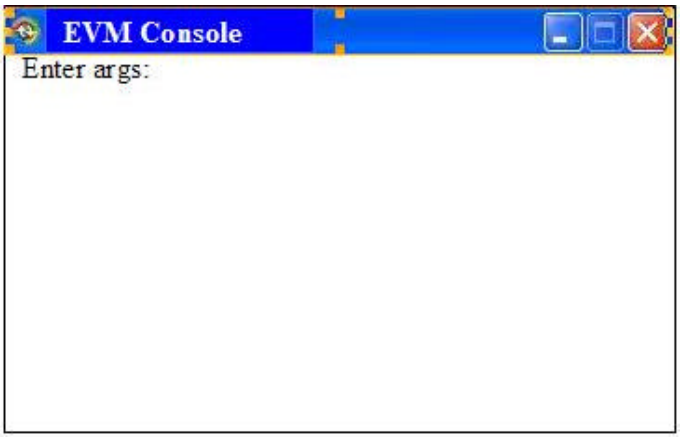

Figure 8. JeodeRuntime EVM console

There are restricted commands, which can be used on the EVM Console. Here are some examples.

-?, -h or -help : help files.

Launch JeodeRuntime can be managed in two ways:

- Running JeodeRuntime as a shortcut
- Tapping on the EVM icon (**Start** > **Programs** > **Jeode**), and entering following :

-classpath <pathnames> or -cp <pathnames**>**

Specify the path(s) used for loading application classes. Semi-colons separate the pathnames. For example, to include classes contained in remotechess.jar, that is provided in this research following command must be entered:

-classpath \Windows\lib\remotechess.jar

-D<propertyName>=<value>

This type of command supplies the value for a JeodeRuntime or standard Java system property. For example, to keep the display console open, use the command:

-Djeode.evm.console.local.keep=TRUE

-v, -verbose

This command causes messages to be displayed on the JeodeRuntime console when a class file or dynamic library is successfully loaded. A garbage collection cycle is performed.

-version

This command displays JeodeRuntime version information on the EVM console.

-Xnowinceconsole

Use the -Xnowinceconsole option to disable the EVM console if its display is unwanted - for example, when running graphical applications.

c. Choosing Java Platform for PC

When developing the application for the iPAQ Pocket PC in Java, JDK (Java Development Kit) 1.2 is used. The most recent version can also be used without problems but in this case no classes other than those in the JDK.1.2 Specification can be used. Latest versions of Java include both JRE and JDK so the user does not have to install these separately.

2. Modeling Chess Environment in VRML

The chess game requires the following models:

- 12 white pieces; King, Queen, Bishop (2), Knight (2), Rook (2), Pawn (8).
- 12 black pieces King, Queen, Bishop (2), Knight (2), Rook (2), Pawn (8).

- 1 chess board.

  A name and the initial positions of the pieces are provided on Table 1

8	brl	bkl	bbl	bQ	bK	bbr	bkr	brr
7	0.06 0 -0.48	0.12 0 -0.48	0.18 0 -0.48	0.24 0 -0.48	0.30 0 -0.48	0.36 0 -0.48	0.42 0 -0.48	0.48 0 -0.48
6	bp1	bp2	bp3	bp4	bp5	bp6	bp7	bp8
5	0.06 0 -0.42	0.12 0 -0.42	0.18 0 -0.42	0.24 0 -0.42	0.30 0 -0.42	0.36 0 -0.42	0.42 0 -0.42	0.48 0 -0.42
4								
3	0.06 0 -0.36	0.12 0 -0.36	0.18 0 -0.36	0.24 0 -0.36	0.30 0 -0.36	0.36 0 -0.36	0.42 0 -0.36	0.48 0 -0.36
2								
1	0.06 0 -0.30	0.12 0 -0.30	0.18 0 -0.30	0.24 0 -0.30	0.30 0 -0.30	0.36 0 -0.30	0.42 0 -0.30	0.48 0 -0.30
8								
7	0.06 0 -0.24	0.12 0 -0.24	0.18 0 -0.24	0.24 0 -0.24	0.30 0 -0.24	0.36 0 -0.24	0.42 0 -0.24	0.48 0 -0.24
6								
5	0.06 0 -0.18	0.12 0 -0.18	0.18 0 -0.18	0.24 0 -0.18	0.30 0 -0.18	0.36 0 -0.18	0.42 0 -0.18	0.48 0 -0.18
4	wp1	wp2	wp3	wp4	wp5	wp6	wp7	wp8
3	0.06 0 -0.12	0.12 0 -0.12	0.18 0 -0.12	0.24 0 -0.12	0.30 0 -0.12	0.36 0 -0.12	0.42 0 -0.12	0.48 0 -0.12
2	wrl	wkl	wbl	wQ	wK	wbr	wkr	wrr
1	0.06 0 -0.06	0.12 0 -0.06	0.18 0 -0.06	0.24 0 -0.06	0.30 0 -0.06	0.36 0 -0.06	0.42 0 -0.06	0.48 0 -0.06
	A	B	C	D	E	F	G	H

Table 1. Initial Positions Chess Game Pieces.

Pieces**:**

(brl: **b**lack **r**ook on the **l**eft)

(bkl: **b**lack **k**night on the **l**eft)

(bbl: **b**lack **b**ishop on the **l**eft)

(bQ: **b**lack **q**ueen)

(bK: **b**lack **k**ing)

(bbr: **b**lack **b**ishop on the **r**ight)

(bkr: **b**lack **k**night on the **r**ight)

(brr: **b**lack **r**ook on the **r**ight)

(wrl: **w**hite **r**ook on the **l**eft)

(wkl: **w**hite **k**night on the **l**eft)

(wbl: **w**hite **b**ishop on the **l**eft)

(wQ: **w**hite **q**ueen)

(wK: **w**hite **k**ing)

(wbr: **w**hite **b**ishop on the **r**ight)

(wkr: **w**hite **k**night on the **r**ight)

(wrr: **w**hite **r**ook on the **r**ight)

Algorithm

When writing an application for the Pocket PC, Pocket PC's restrictions must be considered. If sending a packet to the server as in this application, packet size is very important considering the wireless bandwidth. Hence an algorithm is needed that sends the least number of bits in a data packet possible. The algorithm and associated data used for sending data is provided in Table 2 and discussed below.

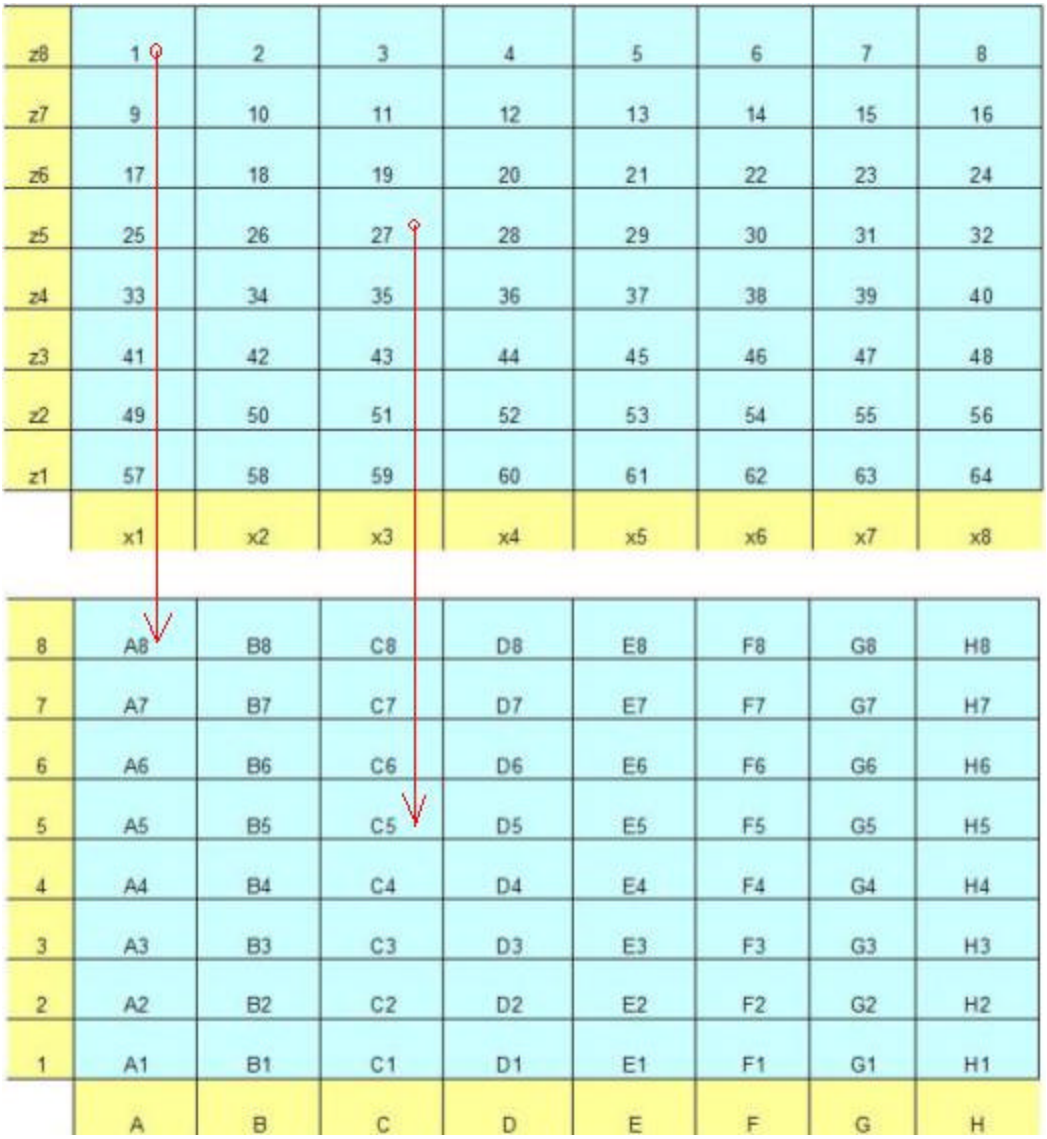

Table 2. Initial Positions Chess Game Pieces.

Each square represents a square on chess board. Traditionally, they are labeled as “A1” or “B2” but for performance purposes two digit representations of squares are used. For example “1” means “A8” and “27” means “C5”. Actually the traditional way was attempted first while testing the demonstration software, but it became apparent that the numeric approach improves performance. The values are used to calculate the new position of a picked piece. For example, the first mouse click by a user defines which square is chosen. The client sends the related square id, such as “1” (A8). When the server receives this data, it finds the mapping piece name by looking at the initialized piece-square mapping table

by using location “1”. At the beginning of the game brl (blackrookleft) occupies square “1”. The server then waits for the second mouse-click from the user. After the second mouse click the ID of the associated square is sent in the same way. If “C5” is chosen, then “27” is sent. In the VRML chess board each square side is 0.6 units. Therefore, to find the new position of the chosen piece, the following calculation is performed:

ID: type=integer, value=27

Translation on X axis = ((ID-1)mod8)+1) * 0.06 = 0.18 unit

Translation on Y axis = Do not update.

Translation on Z axis = ((8- ((ID-1)/8))) * 0.06 = -0.42 unit

Between the first click and the second click the software emphasizes the chosen piece by simulating a spot light illuminating the piece from the top and turning scene headlights off. After the second click, the scene headlight and spot light states are reset.

B. PROGRAM CODE AND EXPLANATIONS

1. Overview

For the communication between the client and server, the following files are used:

Client Side

- ChessClient.java
- ChessView.java
- Cell.java

Server Side

- ChessServer.java
- Mover.java
- Chess.wrl

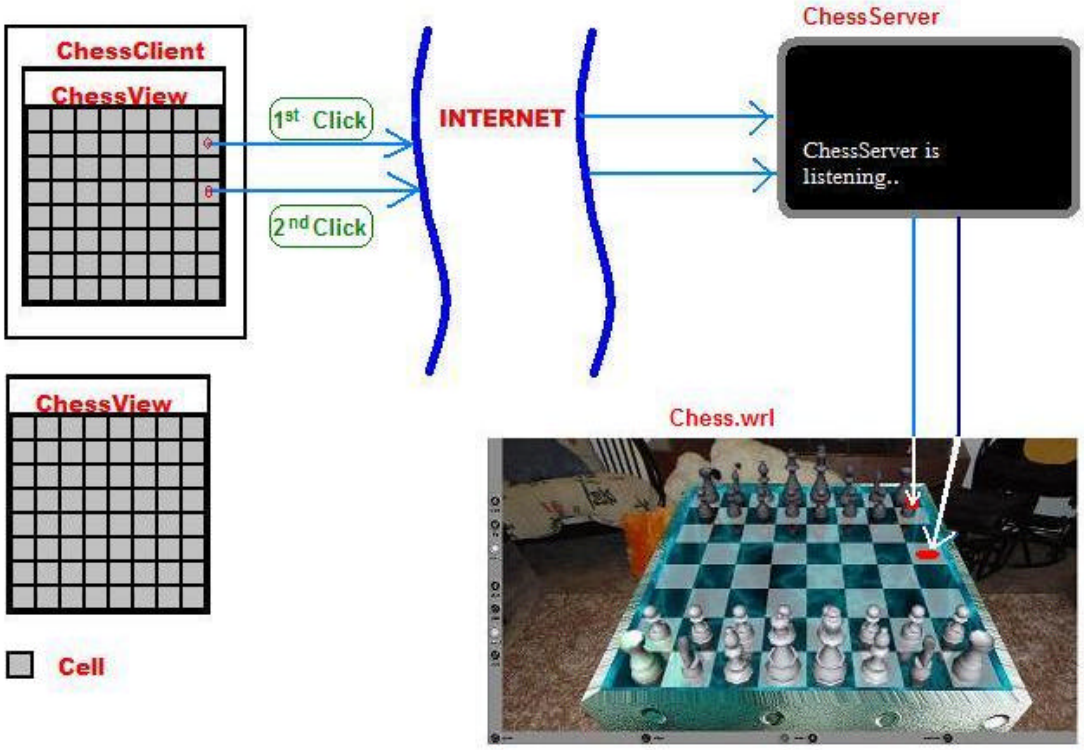

Figure 9. Server-Client Communication Design

2. Java Files

As seen on Figure 9, ChessClient is responsible for handling the mouse events created by user. ChessView is the necessary GUI part of client side. Cell is a GUI component representing each square on the chess board. ChessView has 64 Cell Class objects.

UDP protocol is used to send the data packets since the communication packets are small, and the scene does not need too many updates with short time intervals and the rate of the risk of losing packets is not high. The worst case is that if an error occurred due to packet missing the user can correct the error easily. If he/she sees that the action he/she took did not work correctly, such as if a click to move a piece does not change the position of a picked piece user simply click the button again.

ChessServer is responsible for receiving messages sent by the client. It uses the content of the message as a key and checks the associated piece name from the mapping tables. It also decrypts the message to find the necessary

transformation by applying the message data to the transformation formula mentioned in the previous section. ChessServer passes the new transformation values and the name of the picked chess piece to Mover.java by invoking one of public methods of Mover.java.

Mover.java extends the Java Script Class to be able to communicate with Chess.wrl file. It is responsible for passing new transformation values and the name of the picked chess piece to the Script Node in the Chess.wrl file.

Chess.wrl is the file displaying the 3D Chess environment. This file is the high resolution version of the chess environment to display on the big screen. A highly optimized version of this file is designed for the Pocket PC as the client side GUI component. However due to the Java limitation of Pocket PC Cortona instead of the VRML file, ChessView.java, extending Frame Java GUI component is used for the client side. The Pocket PC version of the chess environment and is provided in the Appendix A as a starting point for future work in this research area.

3. VRML Files

a. Positioning the Pieces

Placing the chess pieces on the board as mentioned in the previous chapter provides enough flexibility to implement necessary Java code to modify the screen. However a new transformation of the piece does not change the Y value since each piece is initialized as tangential to the chess board with a certain Y value. This rule keeps pieces moving on a flat surface (x-z plane)

b. Setting Background

The background of the chess game is made of 6 high resolution jpeg files: front, back, top, bottom, left, right. The pictures are taken from the center of the room which represents where the imaginary chess board is placed. A 2M Sony digital camera and tripod are used for this purpose. The tripod is necessary to keep the camera in place. Otherwise the background view may have a distorted appearance at the connection points of the images.

c. Creating a Glass Chess Board Effect

Glass effect of the board is created by the following steps:

- Setting a transparent color value for the chess board.
- Placing the 180 degree rotated (mirrored) pieces to the bottom of each piece. By doing this the rotated geometry is seen through the transparent chess board.
- Even though it is not a very recognizable effect, using a frosted glass texture to reflect a colorful object improves the feeling of reality in the chess scene. Reflected objects cannot be recognized since the glass is frosted in real life. Because of the unknown reflection on the frosted glass observers assume it is the TV's reflection on the frosted glass.

This fake reflection effect is partly effective since it needs a reflection for any object in the scene. Therefore it doubles the size of the VRML file. However as mentioned earlier one of the purposes of this research is to overcome the memory, CPU and graphics card limitations of Pocket PCs. The realism provided by high-quality PCs on the server side exceeds the capabilities of mobile devices – with the technique demonstrated in this thesis, the mobile user retains the benefits of the capabilities on the server side.

V. TEST AND PERFORMANCE

A. DEMONSTRATION TESTING

1. OVERVIEW

The demonstration product was separated into modules in the design phase of this research. In this chapter, the integration issues of program modules are addressed above the associated screenshots. All modules are implemented but some problems occurred due to Java configurations while connecting the modules. Therefore all modules are tested individually.

2. SCREEN SHOTS FROM DEMONSTRATION

a. Server Side Chess VRML File

Server-Side Chess Player Views:

Figure 10. Server-Side Chess White Player View

Figure 11. Server-Side Chess Black Player View

- **Reflection Effects :**

Figure 12. Server-Side Chess Top View

Figure 13. Server-Side Chess TV Reflection

Figure 14. Server-Side Chess Room Light Reflection

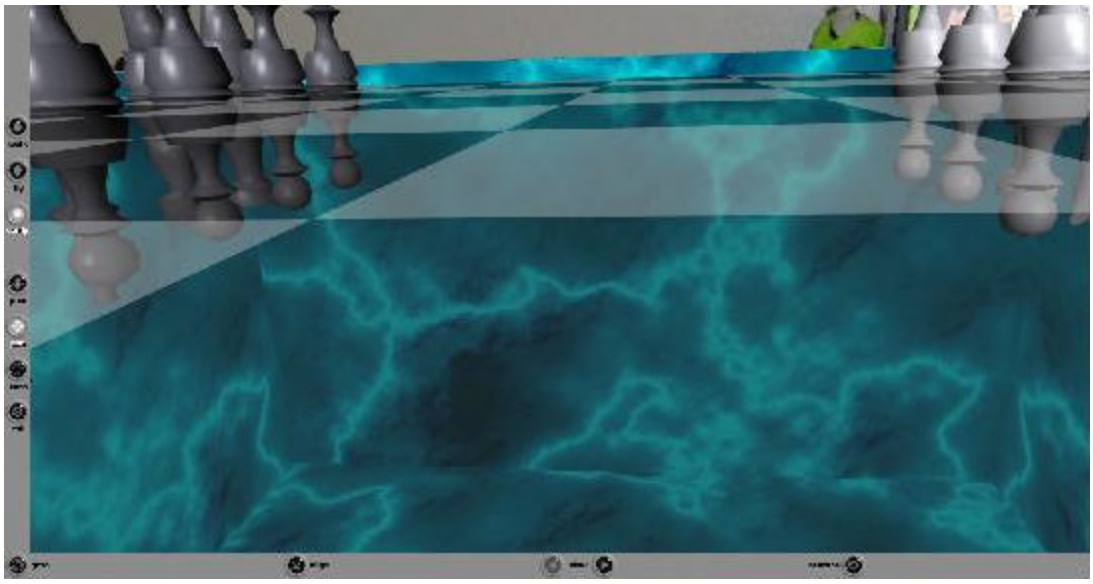

Figure 15. Server-Side Chess Reflection On Glass Board

Figure 16. Server-Side Chess Inside Board Water Reflections

Picked Chess Pieces:

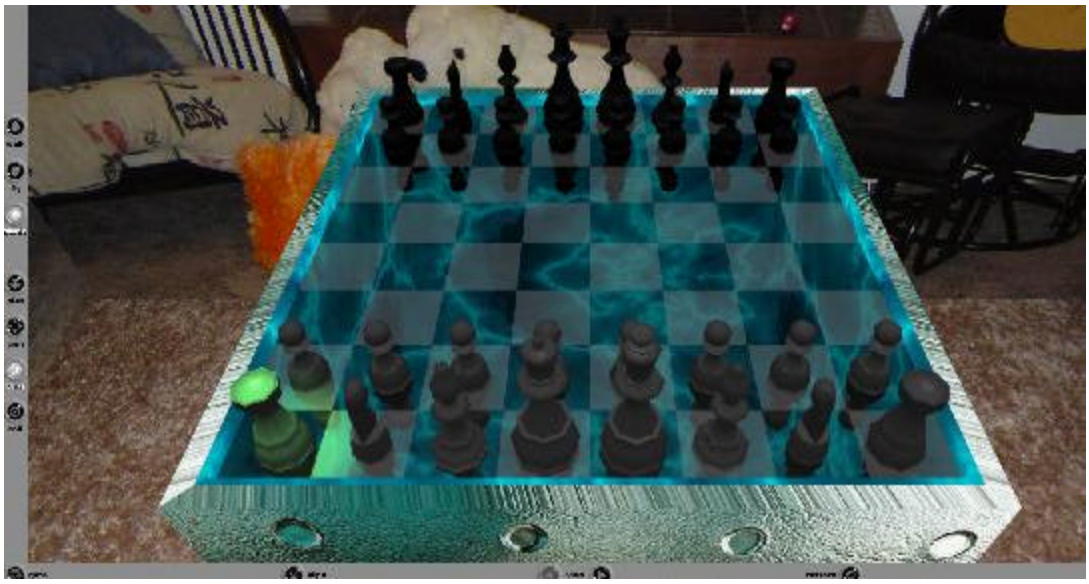

Figure 17. Server-Side Chess Picked Left White Rook (White Player View)

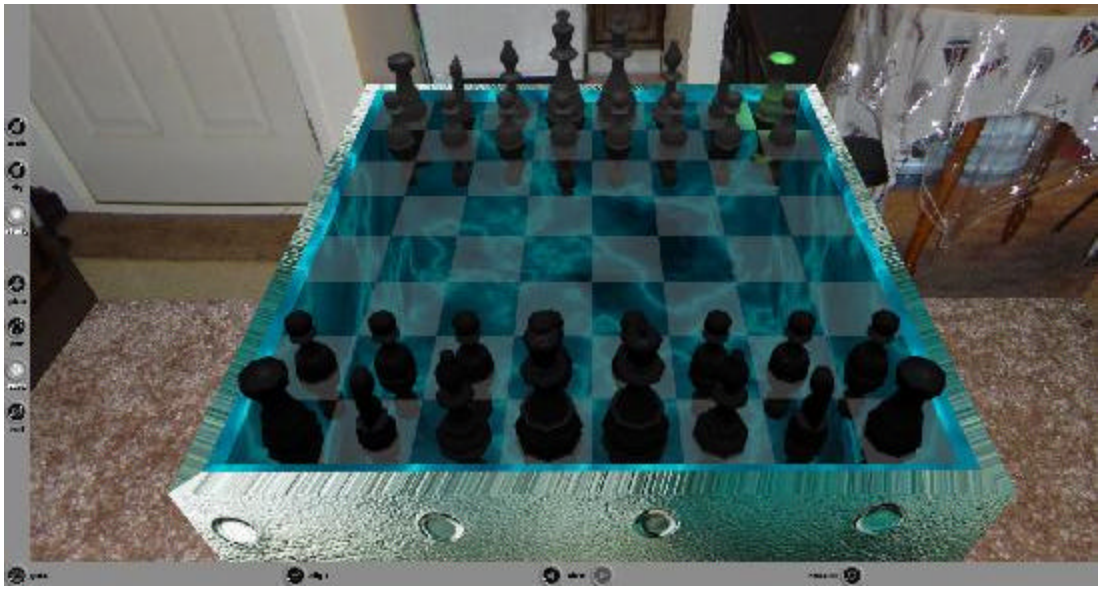

Figure 18. Server-Side Chess Picked Left White Rook (Black Player View)

Figure 19. Server-Side Chess Picked White Queen (White Player View)

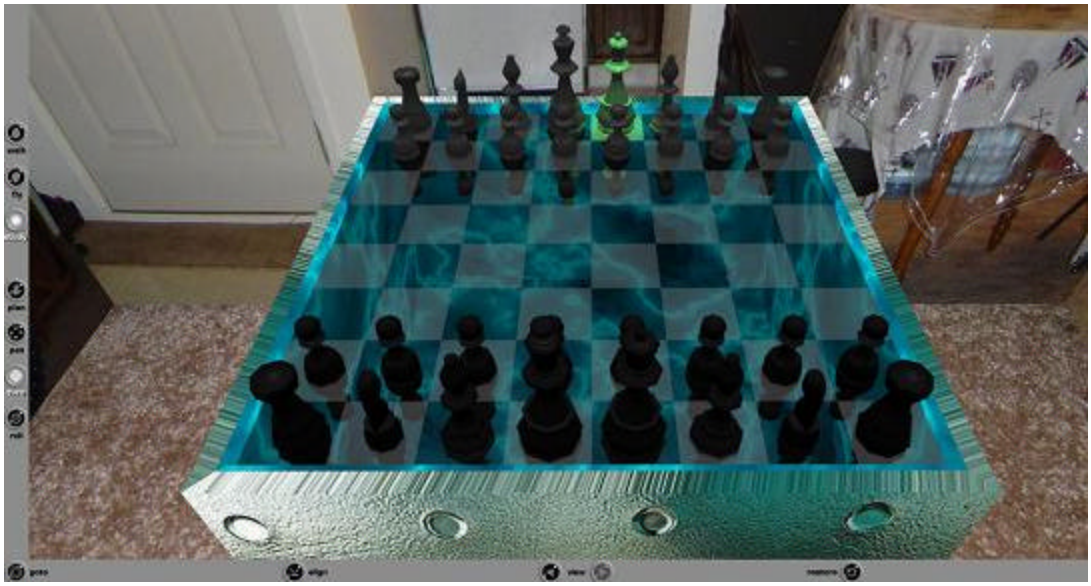

Figure 20. Server-Side Chess Picked White Queen (Black Player View)

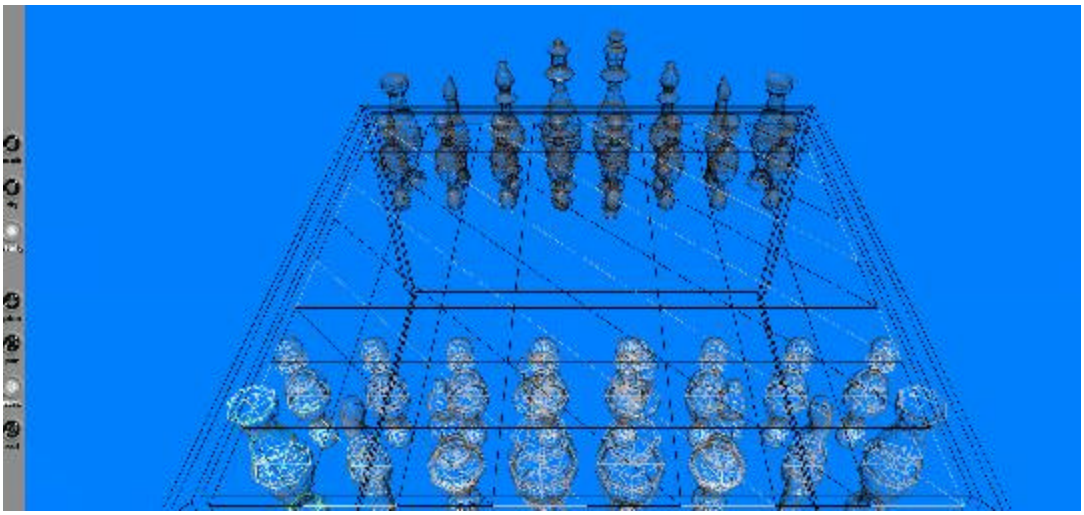

Figure 21. Wireframe view of the scene

Figure 22. Client for Pocket PC

Working Demonstration Screenshots (LocalHost is Used)

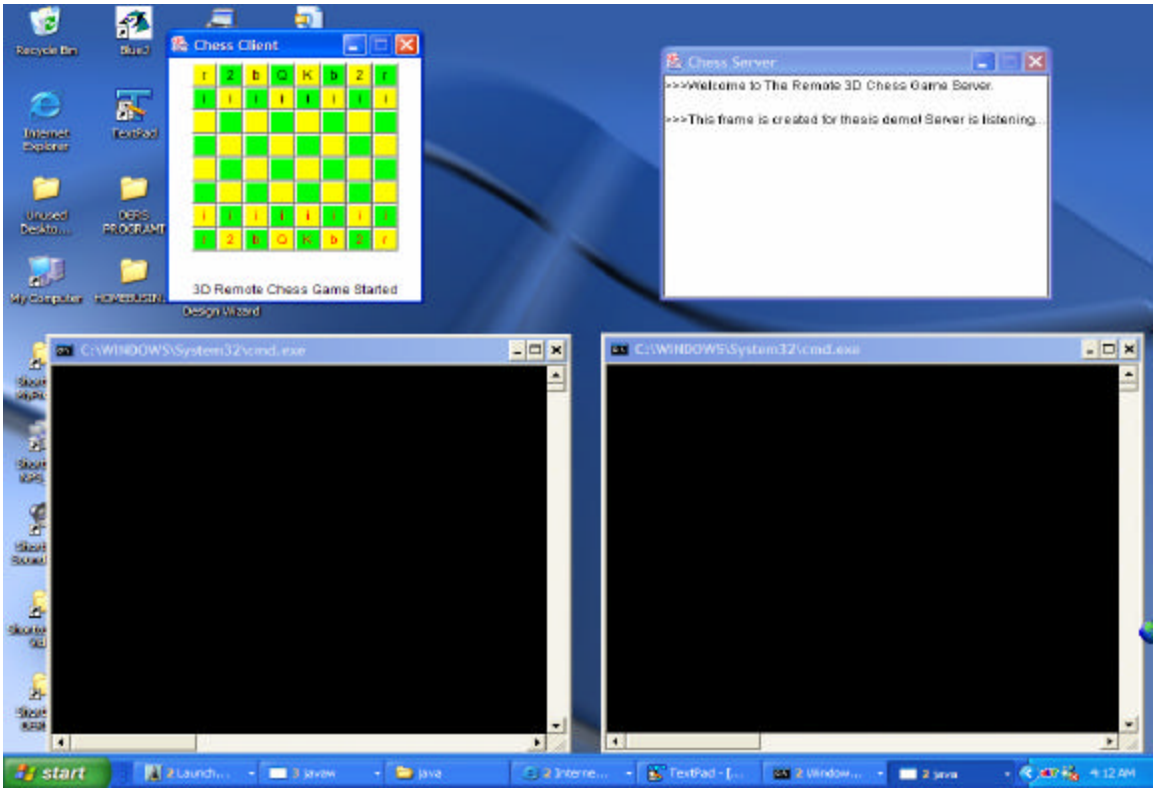

Figure 23. Initializing the client and the server

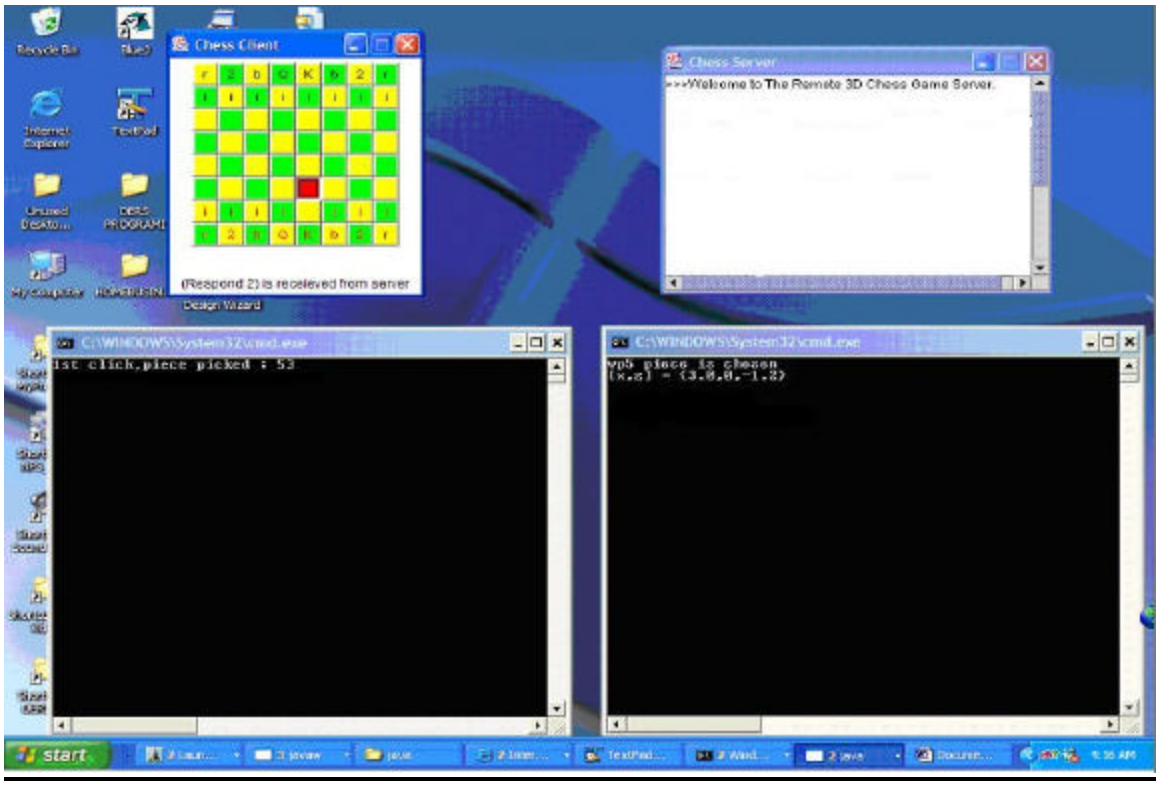

Figure 24. Mouse pressed

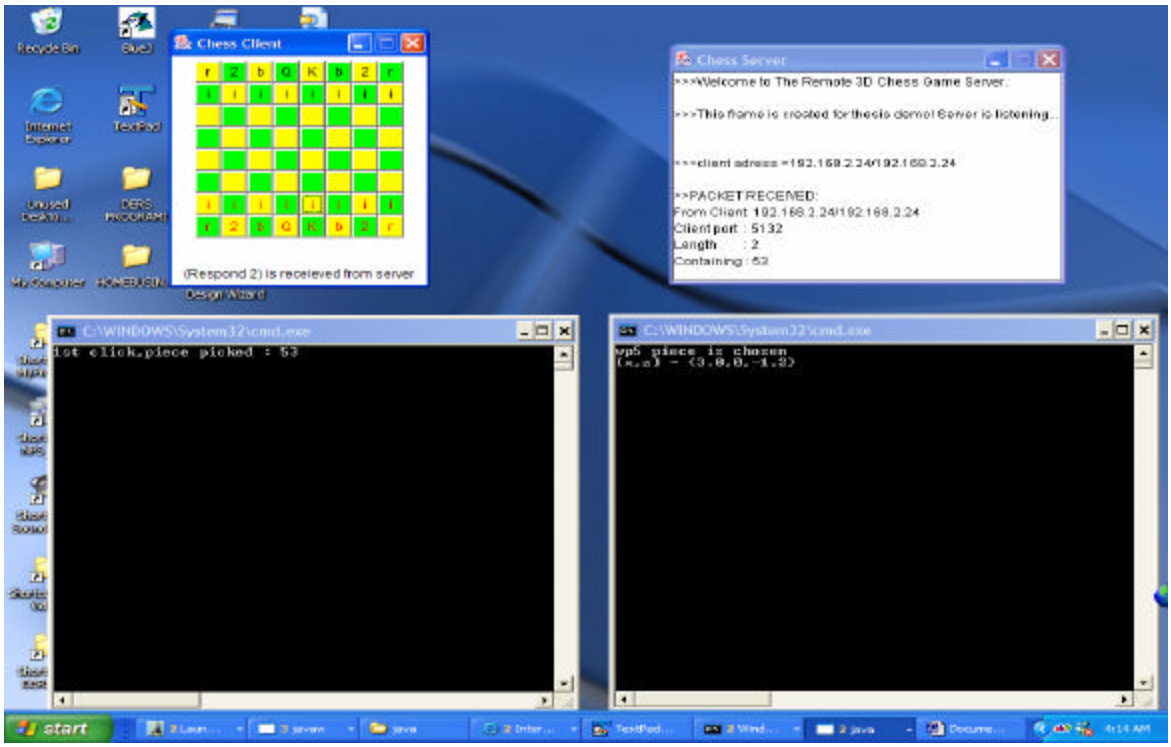

Figure 25. First Click

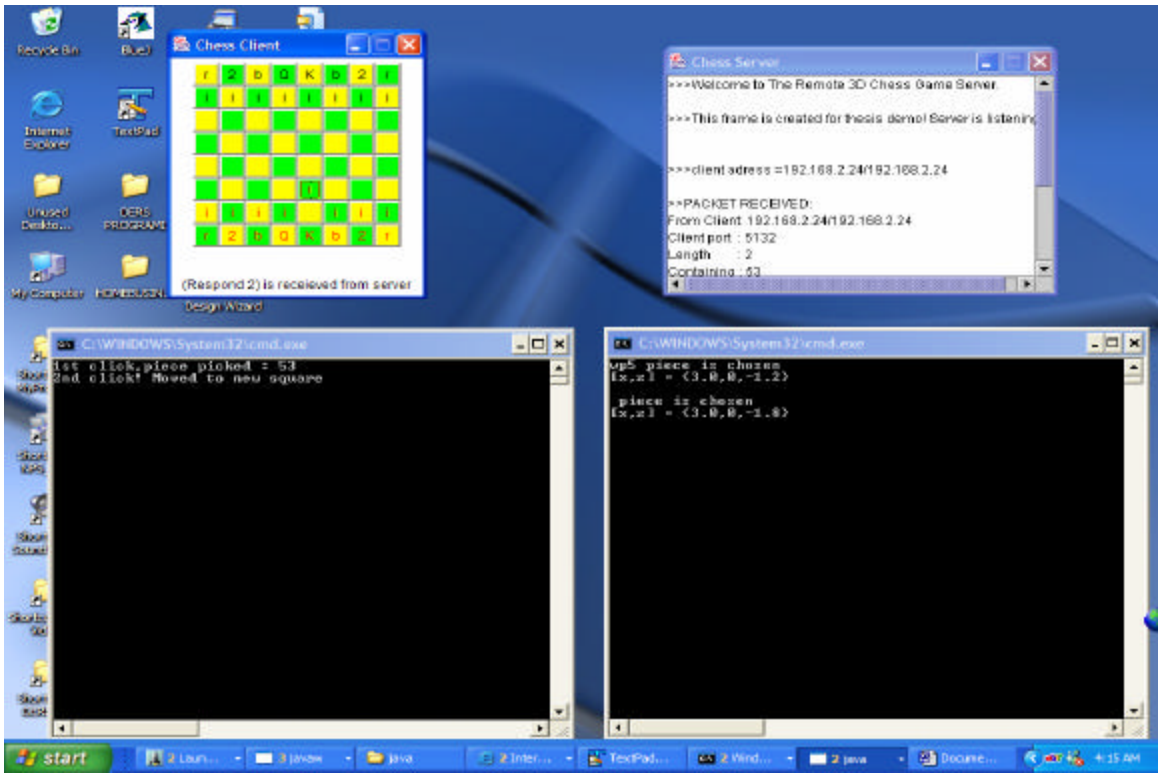

Figure 26. Second Click

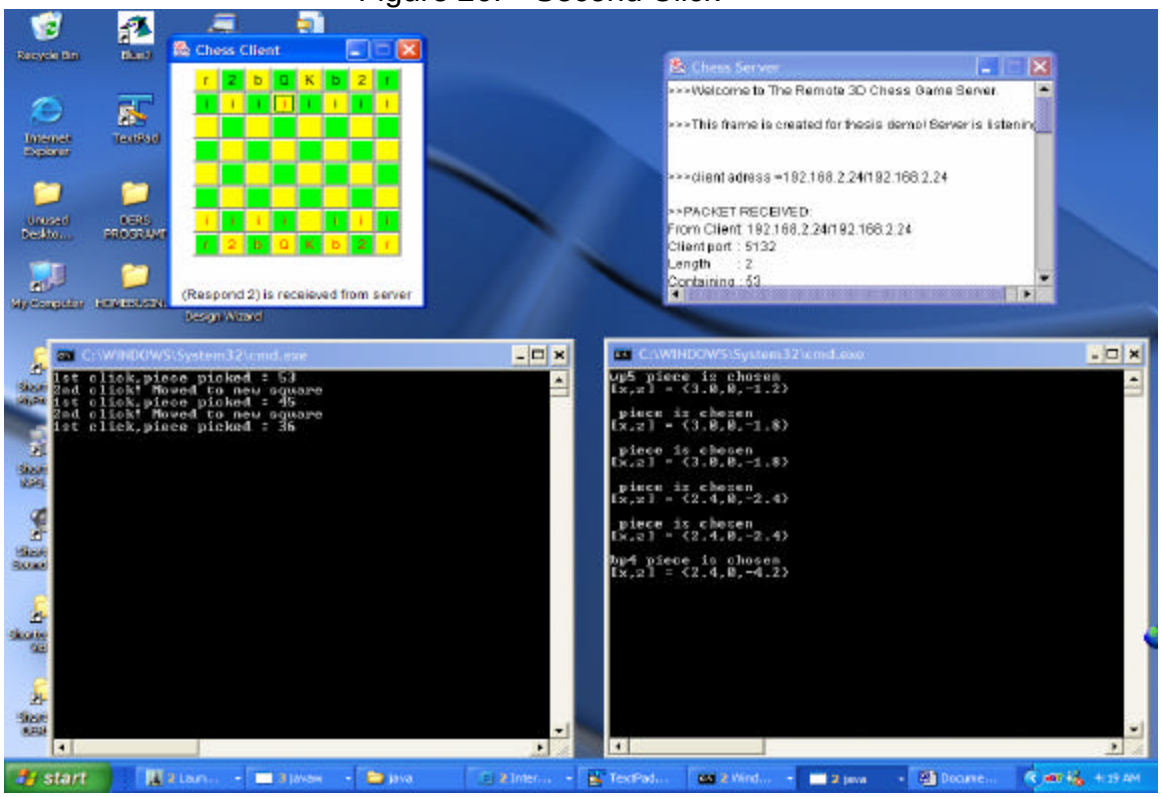

Figure 27. Capturing the opponent's piece

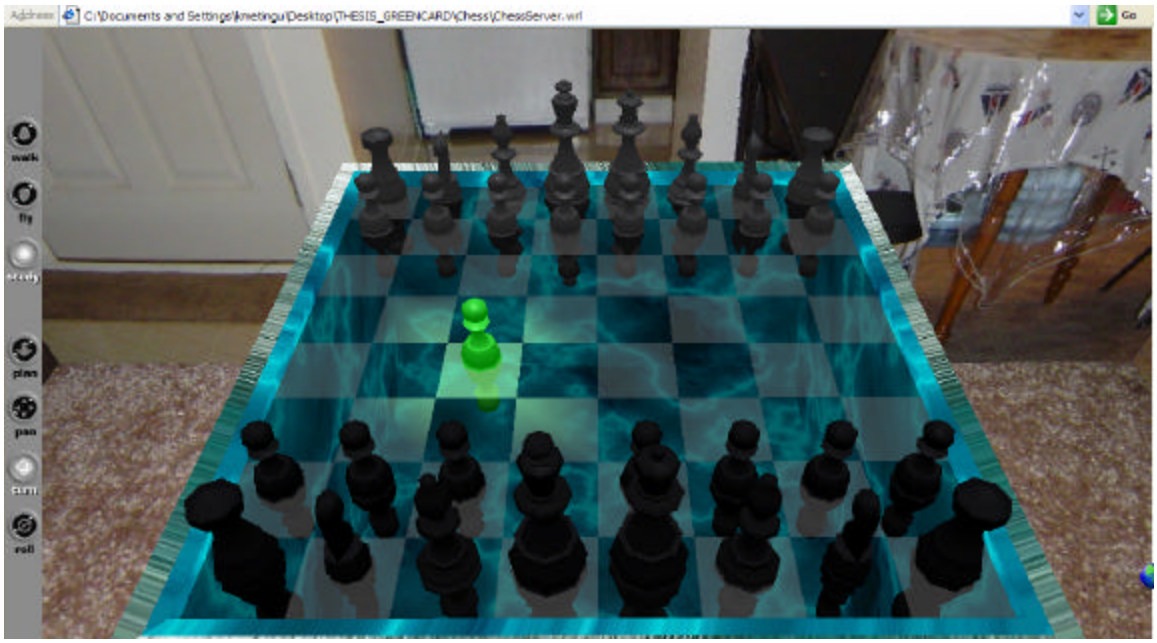

Figure 28. One move in the demo

B. ENCOUNTERED PROBLEMS

There was no significant problem during the implementation period other than configuration problems and some software support problems. The problems are explained in following sections.

1. System Related

For the client side Cortona for Pocket PC of Parallel Graphics is used first. However due to some Java limitations it was not applicable to the design with the current technology. Because the client side VRML file is already implemented and optimized for Pocket PCs it can be used as a stand alone chess game or it can also be used as the basis for future work. The biggest problem with this VRML file was optimizing the file with 3ds max polygon optimizer which caused some odd appearances on piece models. These oddities were not visible until converting it from 3ds max file to VRML file. The size problems also caused drag and drop problems in the VRML file on Pocket PC. After decreasing the size 1/10, the speed and accuracy of piece moves become very usable. The complete VRML files can be found in Appendix A.

The Mover Java file which extends Script did not work with the computer used for the thesis due to a Java security error. Even though the client–server connection and data transfer are achieved, the server which is supposed to feed the Mover with new transformations could not invoke methods of the Mover Class. The methods and interaction between Java files was checked carefully and no logical error found. The Java code part which provides this interaction between the Mover file and server is currently commented out but was not deleted. For demonstration purposes the part the server is supposed to do is adapted to Mover files so it can feed the server side VRML file with new transformations. The Java code is provided in Appendix A.

2. User Related

No user related problems were encountered in the demonstration software.

VI. CONCLUSIONS AND FUTURE WORK

A. CONCLUSIONS

The objective of this thesis, and of the research upon which it was based, was to improve collaboration in common space by providing a new system model for wireless entity control in virtual environments. The main deliverable of this thesis is a demonstration of a new system model which provides both mobility and reality by implementing a remote control approach for virtual environments using mobile devices. The new model has been applied to a simple chess game. The demonstrated approach may be used for other virtual environments and relevant areas with a few modifications on both server and client sides.

Research progressed in four main phases:

- Review of current related technologies, such as Wireless Technologies and Graphics Technologies. This was accomplished (Chapter II).
- Review of current systems similar to the demonstration-product of this research, such as Mobile printing system and Chess Game for PCs and Pocket PCs. This was accomplished (Chapter II).
- Identification of a better possible server-client system for a chess game that doesn't sacrifice reality while providing mobility by using current technology. After carefully reviewing similar systems, the work developed a new model for remote control of entities in a virtual environment. The design approach was described in Chapter III.
- Development of the demonstration server-client application which provides more effective usage of the mobile devices for a remote control in a virtual environment. This research successfully implemented a server-client approach that provides high-quality graphics and high performance computing on the server side with

economical processing demands on the client side. This was described in Chapter IV. Specific capabilities and limitations in the implementation were further discussed in Chapter V.

The primary goal of this thesis was to answer the following questions:

- By implementing software programs for mobile devices, can we create human collaborative interaction in distributed common space of virtual environments with mobile users? Based on this research, this goal is certainly achievable within the constraints of the mobile devices.
- By implementing software programs for mobile devices, how can we widen the usage of virtual environments in daily life? This research has shown the possibility of mobile control over entities in a virtual environment for multi-player entertainment, creating new opportunities for wider adoption of virtual environments in daily life.
- By applying a new server-client model for collaborative mobile device applications can we improve reality and mobility? Using mobile devices as remote control gives the user the advantages of mobility over desktop PCs. On the other hand, the realism provided by high-quality PCs on the server side exceeds the capabilities of mobile devices – with the technique demonstrated in this thesis, the mobile user retains the benefits of the capabilities on the server side.
- With a prototype capability can we identify constraints, limitations, and performance? From this research, it was not clear how to overcome problems with Cortona and current Java versions. Workable techniques or alternatives need to be explored further.

B. FUTURE WORK

The new system design introduced by this research opens a new door to virtual environments. The main concept of this research may be applied any other games and interactive virtual environments.

Special to the demonstration of this research, the new technologies which give ability to display VRML files on Pocket PC should be monitored to be able to use a VRML file as a graphical interface for the client–side of the remote chess game. Multi-user capable browsers do not support Pocket PCs yet so in the future new capabilities of these browsers should be monitored and employed to enable multi-user capability in the chess game. The fundamental design used in this thesis can be employed in other games or to control entities in quite different virtual environments, for example to control entities in a military simulation.

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APPENDIX PROGRAM AND DEMONSTRATION FILES

Client-side VRML File

Full Application Software Files

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2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

3. Don Brutzman
   Naval Postgraduate School
   Monterey, CA

4. Gurminder Singh
   Naval Postgraduate School
   Monterey, CA

5. LTJG Ekrem SERIN
   Arastirma Merkez Komutanligi
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6. LTJG Mehmet Guzey
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